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Worldwide Report

NUCLEAR DEVELOPMENT AND PROLIFERATION

No. 145

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CONTENTS

HIGH HOPES FOR NUCLEAR POWER DEVELOPMENT BELIED

Madras THE HINDU in English 20 Apr 82 p 8

[Editorial]

[Text]

THE NUCLEAR POWER sector is one of the critical fields of development in which high hopes raised earlier have been sadly belied. Whatever the capabilities of Indian scientists—and the accepted tall international stature of some of them—for one reason or another the work translated on to the ground has not been of the order expected. This is the silver jubilee year of the Bhabha Atomic Research Centre, Bombay. BARC, together with the Tata Institute of Fundamental Research, forms the springboard of the nation's nuclear programme. The activities of the Department of Atomic Energy have been shrouded in greater secrecy than the functioning of other wings of the Government. This feature makes it difficult to pinpoint the errors of commission and omission. The future of the first nuclear power plant at Tarapur, in commercial operation since October 1969, is clouded in view of the discord over the American supply of enriched uranium. This plant is being run at sub-optimal levels due to the shortage of the primary fuel. Because Canada went back on contractual obligations after the Indian nuclear test in May 1974, the Rana Pratapsagar station in Rajasthan was delayed. The first unit there had been operational since the end of 1973, but the second went into commercial operation in April 1981 after heavy water was obtained from the Soviet Union. The conditions governing this supply were stringent, since the Russians were also as insistent as the Western nations on the discriminatory safeguard clause under the nuclear non-proliferation treaty. The water leak in the Rajasthan station has also upset the power generation programme. The shutdown of this unit for several months indicates the complex operational and safety problems in nuclear power-houses.

The Madras Atomic Power Project, at Kalpakkam, has been delayed by many years. It is several months since the station is said to have been ready for commissioning, but the needed heavy water is not in sight. Obviously, the Government of India is not inclined to opt for purchases from abroad under restrictive conditions. The Baroda and Tuticorin heavy water plants have yet to overcome technical snags. It is difficult, therefore, to accept the Atomic Energy Department's promise in its annual report that Kalpakkam will be commissioned this year. Under the old Sarabhai plan 2,700 MW of nuclear plants were to have been in place by 1980. The installed capacity is now a meagre 860 MW, with construction going on at Narora in Uttar Pradesh. A plan drawn up by the Atomic Energy Commission envisages installed nuclear power capacity of 10,000 MW by the end of this century. This aim is out of reach, if the present state of affairs is permitted to continue.

CSO: 5100/7085

BRIEFS

NUCLEAR TEST--According to the INDIAN WEEKLY Sunday, India is to carry out its second nuclear test at the Pokhran site in the Rajasthan desert. It says the Indian army has sealed off the test site and the local population has been asked to remain ready for evacuation shortly. [Text] [BK111017 Karachi Domestic Service in English 1005 GMT 11 May 82]

THORIUM UTILIZATION STUDY--New Delhi, (INFA)--The Department of Atomic Energy has drawn up a long-range programme for the utilization of thorium for power production. A separate reserach centre has been set up for testing thorium for the production of energy in fast reaction. Thorium reserves in India are much larger than known uranium reserves. It is the Department's intention to make optimum utilization of thorium. [Text] [Bombay THE TIMES OF INDIA in English 19 Apr 82 p 13]

CSO: 5100/7084

ISLAMIC COOPERATION IN PAKISTAN'S ATOMIC PROGRAM URGED

Rawalpindi TAMEER in Urdu 15 Mar 82 p 2

[Article: "The Philosophy of Islamic Bomb"]

[Text] President Zia-ul-Haq, during an interview with a Saudi paper, as he explained Pakistan's limited nuclear program, also questioned why it is branded as an "Islamic bomb." The United States, Israel, the Soviet Union and India are also atomic powers. Why aren't their bombs called "Christian bomb," "Jewish bomb," "communist bomb" and "Hindu bomb?"

President Zia has said this before and has reiterated it. In our view the Islamic countries are fully aware of this issue. Islamic countries have an important place of power in the world with respect to their numbers, population, area and issues. But their importance is mentioned only when other countries have an axe to grind with them and want to use them. Otherwise, their political importance, economic progress and technological advance are not looked on with favor.

Pakistan is a country with limited economic resources. Overpopulation and poverty are common. In spite of this and the difficulties created by the recurring political crises and neighboring countries, its people have made special efforts to overcome their backwardness in technology. The result of that effort is that Pakistan has reached the point where it can become a nuclear power in a few years if it so wishes. But this very capability bothers other countries, even those who claim to be its friends.

Pakistan does not have all of the technical resources and materials needed to be an effective nuclear power. All of the powers are aware of this. Therefore, they are not worried about that as much as they are about other Islamic countries entering the modern era because of Pakistan's progress in nuclear science.

Pakistan has always expressed feelings of friendship and cooperation toward the Islamic countries. Therefore, other powers believe that Pakistan will never hesitate to include fraternal Islamic countries in its technological progress.

The prejudice that is found in other countries toward Islamic countries is actually responsible for the branding of nuclear progress in Pakistan as being Islamic. The Islamic countries should make a special note of this.

If Pakistan's nuclear program is an Islamic program, then it is the duty of all Islamic countries to devote all of their resources to making it a reality. Help should not be limited to Pakistan. If any Islamic country has the capacity to move forward, it should be the duty of all Islamic countries to help it and to accelerate the rate of its progress.

9859
CSO: 5100/5460

SERIOUSNESS OF PAKISTAN NUCLEAR 'THREAT' QUESTIONED

Bombay THE TIMES OF INDIA in English 20 Apr 82 p 8

[Article by Ravi Rikhye]

[Text]

DESPITE all that has been said and written on the subject, it remains necessary to ask whether Pakistan is in fact close to being in a position to conduct a nuclear test. My answer is firmly in the negative.

Pakistan has to obtain fissile material for the purpose. This can either be uranium-235, which is obtained as a by-product of using natural uranium to fuel a heavy-water reactor.

Pakistan has been trying to construct an enrichment facility at Kahuta. Latest reports suggest that the project is all but dead. This is not surprising in view of the complexity of the problems involved in setting up a centrifuge facility. It is not, in my opinion, reasonable to assume that Pakistan could assemble a centrifuge just by stealing the design for one and by clandestinely acquiring the necessary equipment.

In theory, Pakistan can obtain plutonium-239 by interpolating its own fuel rods into the Karachi nuclear power plant. It has natural uranium, and has been fabricating its own fuel rods for some time. The International Atomic Energy Agency (IAEA) has recently said that it is no longer possible to ensure that Pakistan does not divert nuclear material from the Karachi station. This amounts to an indictment of Islamabad. But there is so far no evidence to show that Pakistan has actually done so.

Moreover, even if Pakistan obtains plutonium in this fashion, it will gain little, because civil reactor grade plutonium contains too high a percentage of an undesirable isotope, PU-240, to serve its needs. A special plutonium production reactor is needed for the job, which Pakistan does not possess.

This raises the question whether Pakistan can get fissile material from the black market. The uranium available in the black market is generally three per cent enriched. It is suitable for reactors which generate electricity. For weapons, one needs the 90 per cent enriched uranium. Such uranium is produced in very high-security plants where the chances of diversion are minimal. Similarly, plutonium-239 comes from tightly-guarded production reactors. The plutonium in the black market comes from civil electricity generating reactors. Again, this contains too high a percentage of plutonium-240 for a successful explosion.

Enrichment Plant

The chances of Islamabad completing the Kahuta enrichment plant or setting up a special plutonium reactor are not very good, since the US is doing its best to stop nuclear-related equipment from reaching Pakistan. Even if Pakistan were free tomorrow to buy the necessary equipment, it might require ten years to complete either project.

Try as Pakistan might, it is unlikely to manage to produce a bomb during the 1980s. But one day it could conceivably obtain the needed fissile material. What then?

The first possibility that has to be faced is that Pakistan may not explode a bomb even when it acquires the capability. It has much to lose by becoming an overt nuclear power, by way of US assistance. Weakness requires secrecy. A Pakistan with fissile material for just a few bombs, and needing a lengthy period to develop a deliverable warhead, will be exposed to the risk, however small, of retaliation by India, the Soviet Union, Israel and the United States. But if it keeps quiet, the others will

assume the worst. This is already happening. In India we talk as if Pakistan is about to explode a bomb at any time. In Pakistan, it is commonly assumed that India is already a covert nuclear power.

A covert Pakistan bomb will create difficulties for us. Whereas an explosion will unite India into going nuclear with a vengeance, we will be unsure of how to deal with the situation if Islamabad does not demonstrate its capability. It is possible that it will create enough uncertainty to deter India in a crisis. There might be only a small chance that an untested Pakistani bomb will work on delivery, but New Delhi might not want to take the risk.

Unlike India, which is yet to articulate clearly a strategic doctrine for nuclear weapons, Dr. Stephen Cohen suggests that Pakistan already has evolved one. Dr. Cohen is unique among American scholars in that he is welcome and trusted in both India and Pakistan. From what he has been told by Pakistanis, it appears that its primary purpose is deterrence against India; next comes prestige, and last, the expectation of coercive use. Pakistanis envisage the possibility of using the nuclear cover to protect a conventional grab of Kashmir if the Indian government is weak. But this must be only a theoretical formulation. For a nuclear Pakistan necessarily means a nuclear India and all that it implies. Islamabad also cannot be sure what New Delhi will do in such an eventuality.

Attack Aircraft

If Pakistan should go nuclear (or, as some would argue, *when* Pakistan goes nuclear), the question of delivery capability will arise. Pakistan's standard attack aircraft is the Mirage-5, which has very limited range at low level. With a one-ton payload it is unlikely to do better than a 160-kilometer radius. The main threat will then be to Punjab, a circumstance that may have wide repercussions even if India itself has the bomb. No nuclear power to date has to live with the knowledge that only one particular part of its territory is vulnerable.

At high level, the Mirage-5's range increases, so that with aerial refuelling, attacks as far south as Bombay become possible, but given India's air superiority, a high-level attack may have a very low probability of success. The F-16's Pakistan will be acquiring, are incapable of delivering nuclear weapons.

This, plus the limited mirage 5 radius indicates that Pakistan must look for a new aircraft. Had it been serious at this stage about a nuclear delivery capability, it would have chosen the A-7 Corsair 11. The A-7 was proposed for sale to Pakistan in 1976, but vetoed by the Carter administration. This plane is a superb light bomber, unlike the F-16 which has only a secondary attack capability.

Mr. Ravi Rikhye contests the widespread view that Pakistan is in a position to go in for a nuclear explosion in the foreseeable future. We publish his article in order to draw attention to this view.

India may find an aircraft threat from Pakistan manageable. Using airborne early warning and control aircraft plus interceptors armed with long-range shoot-down missiles, a high percentage of attackers can be taken care of. The U.S. navy regularly turns in 100 per cent kills with its Hawkeye | Tomcat combination in exercises held against foreign aid forces. This in turn raises the possibility that a Pakistan nuclear bomb may not prove a real deterrent against a determined Indian leadership.

If India initiates a crisis, it can make a conventional pre-emptive strike against Pakistan's nuclear-armed aircraft, and count on a sophisticated air defence to take care of aircraft which escape the initial attack. Of course, India would not take the risk except for the very highest of states. But that is a different issue.

Assuming we are convinced that Pakistan will at some undefined future time, go nuclear, what should we do? Most Indians would say, "we must respond." But this is wholly inadequate.

First, there may be sound re[illegible] for India to go nuclear, regardless what Pakistan does. A recent seminar held at the centre for policy research, New Delhi, grappled with just such issues. Though a wide range of views emerged, there was a consensus that Pakistan should not be allowed to determine India's nuclear programme.

Secondly, an adequately nuclear-armed Pakistan will once and for all foreclose India's options vis-a-vis Kashmir and the rest of Pakistan. The term "adequately" is used because, as already mentioned, India might not be deterred by just an aircraft threat from Pakistan.

India has violently resisted the notion of Pakistan acquiring military parity with it. A nuclear-armed Pakistan will achieve precisely that parity. Pakistan will then be in a position to determine our responses to that country.

CSO: 5100/7086

BRIEFS

PROTEST OF FRENCH N-TEST--PORT MORESBY--The Papua New Guinea Foreign Affairs and Trade Minister, Mr Levi, has called for "a chorus of protests" over the latest French nuclear bomb test on Mururoa Atoll in French Polynesia. Last Sunday the New Zealand Industrial Research Department recorded a 15-kiloton blast at Mururoa. The explosion was the 48th underground test on the atoll since 1975. Papua New Guinea's protest at the latest test is the strongest yet voiced on the issue, especially as Mr Levi and the Fiji Prime Minister, Ratu Sir Kamisise Mara, returned from Paris only a fortnight ago after protesting directly to French President Mitterrand. Mr Levi said: "It appears the French Government has no regard to the opinions of groups or the rights of island people." He said if Pacific island nations stopped voicing their anger at "the continued nuclear contamination" of the environment, their dreams of a nuclear-free Pacific would be irrevocably lost. France's attitude was another case of small countries being pushed around by countries with economic and military strength, he said. In Paris, the French Defence Ministry refused to comment yesterday on reports that France had exploded a nuclear device underground on Mururoa. [Brisbane THE COURIER-MAIL in English 27 Mar 82 p 12]

CSO: 5100/7527

BRIEFS

URANIUM PURCHASE--Kuwait has taken a more serious step with regard to plans to build nuclear reactors with Canada's cooperation. An agreement was signed with Niger worth 40 million pounds sterling to buy a third of the production of the Tassa N'Taghalgue Company for the Production of Uranium. The capital of this company is divided among the government of Niger and the French General Nuclear Materials Company (COGEMA). Saudi Arabia has received two Nigerien ministers but no agreements to buy uranium have been announced even though Saudi Arabia's aid to Niger is valued at 30 million pounds and represents 70 percent of the total aid received by this poor African nation so rich in uranium. [Text] [Amman AL-UFUQ in Arabic No 3, 14-20 Apr 82 p 9]

CSO: 5100/4720

INTEREST IN ACQUIRING NUCLEAR REACTOR FROM UK REPORTED

TA021203 Tel Aviv HA'ARETZ in Hebrew 2 May 82 pp 1, 2

[Report from London by Yosi Melman]

[Excerpts] London, 1 May (Special to HA'ARETZ)--Israel is interested in acquiring from British companies, an atomic reactor for generating electricity, the HA'ARETZ correspondent has learned from authoritative sources. Israel's request in this matter is part of what appears as a comprehensive effort to attract British investors for the development of energy resources in Israel, including oil exploration in the Mediterranean, development of coal industry and solar energy.

However, the plan to establish an atomic power station was the chief objective of the visit to Britain last week by energy and infrastructure minister Yitzhaq Berman.

It has been learned that Minister Berman met with representatives of leading British companies in the atomic power stations market. Despite the blackout imposed on the talks, it has been learned that one of the companies with which Minister Berman had contact is the G.E.C. [General Electric Company], the manufacturer of atomic reactors and power stations, which is headed by the Jewish businessman, Lord Weinstock.

The second company is the planning and consulting firm for nuclear power stations in London. Minister Berman declined to comment on the report, but informed sources said this was his second visit to Britain in the last 3 weeks on this matter.

Along with the talks in Britain, Israel is conducting contacts with companies in France, the United States and Canada. However the main obstacle to carrying out a deal for the purchase of a nuclear reactor for generating electricity is political: Israel's refusal to sign the international convention to prevent the proliferation of nuclear arms.

Recently, Israel has found greater readiness on the part of international companies including British ones to cooperate in working out a new formula that might enable Israel to buy a nuclear reactor priced at about a billion dollars without signing the nuclear nonproliferation convention.

According to this formula, the deal would receive final approval before the completion of the power station's construction, which would take about 10 years. This approval would come from the concerned government and not before the signing of the contract. According to the sources, the international companies with which Israel is maintaining contacts have agreed to try to persuade their governments to accept the formula.

CSO: 5100/4719

TWO NEW NUCLEAR PLANTS TO BE CONSTRUCTED

Tel Aviv MA'ARIV in Hebrew 25 Mar 82 p 16

[Article by Avraham Peleg, MA'ARIV science correspondent: "David Hago'el at the Meteorology and Energy Conference: Nuclear Power Plants Will Be Set Up in the Halutza Area"]

[Text] Nuclear power plants will be set up in the Halutza area. At the first stage there will be two units, each producing 900 megawatts. Afterwards two more units will be set up, of similar output. The intent is to complete the set-up of one or two nuclear reactors by 1994. These details were released by David Hago'el, chairman of the electric company directorate. He spoke at a festive dinner held in honor of the first scientific conference for "meteorology and energy in Israel 1982," which ended yesterday at the "Princess" hotel in Netanya. The conference lasted 2 days.

David Hago'el reported to MA'ARIV that today's estimated investment for each of the nuclear power plants that are to be started shortly is $1 billion. Israeli operatives are frantically scouting nuclear reactor manufacturers in Europe, the U.S. and Canada. Hago'el noted that the fact that Israel is not a signatory of the nuclear non-proliferation pact makes contact with nuclear reactor manufacturers more difficult, but the manufacturers are today languishing in an economic crisis and are therefore open to commercial contact.

With the operation of the plants, the division of electrical generation sources will be as follows: nuclear energy--20 percent, coal--60 percent and the rest--oil and other sources.

Total electrical output in Israel today is about 2000 megawatts. With the completion of four power units (coal-fired) in Hadera in 1984, Israel will generate 3400 megawatts of electricity.

Professor Yuval Ne'eman noted in a precis that was presented to the conference-goers that environmental considerations determined the preference of the Qatif-Metzada layout for the two-seas canal project.

Professor 'Adi'el Cohen, of the department of atmospheric sciences at the Hebrew University, lectured on changes in radiation in the Dead Sea region. He said that changes at the level of 50 percent have occurred in the evaporation of Dead Sea water as a result of changes in radiation.

The chairman of the conference, engineer Abraham Shechterman--who serves as the chairman of the Mediterranean Sea-Dead Sea company--said that the length of the two seas canal would be 115 kilometers and the length of the tunnel in the canal would be 80 km. It would be the second longest canal in the world.

Professor Y. Tadmor, the coordinator for nuclear research in Nahal Shoreq, said that the coal used for the oepration of power plants contains tiny amounts of radioactive substances. Following combustion a portion of these substances is vaporized and released into the atmosphere. Humans are therefore likely to be exposed to radiation. He added that the radiation influences the respiratory and digestive systems, since man also swallows food that his absorbed radiation. The population residing near the coal-fired plant absorbs an amount of radiation equivalent to that caused by the operation of nuclear power plants--and sometimes even more.

The head of the center for energy research at the Weizman Institute, Professor Israel Dostrovski, reported at the conference that a "solar tower" will be set up at the Institute at the center of a collector field. He lectured on the exploitation of solar towers for the distribution of energy on a large scale. Basic collector technology was developed at five places in the world for the generation of electricity. But the "solar tower" programs of the Weizman Institute were not intended for the distribution of electricity, but for the distribution of industrial and chemical-reactive energy. "These kinds of energy are no less important to us than electricity," the Weizman Institute scientist said.

Y. Porat and A. ben Dov, of the research and development branch of the electric company, reported on company programs for the exploitation of wind energy in Israel. In the framework of this research, a wind turbine will be set up in 1983, and in years 1985-1986 the first wind turbine farm will be established.

9794
CSO: 5100/4714

HELICON URANIUM ENRICHMENT COUNTERS WORLD NUCLEAR SANCTIONS

Capetown DIE BURGER (SUPPLEMENT) in Afrikaans 27 Apr 82 pp 2-3

[Text] It is already generally known that South Africa has a uranium enrichment process and that in the mid 1980's it will go into production with a large enough capacity for providing for South Africa's own needs. What perhaps is not so generally known is the role which uranium enrichment plays in modern nuclear technology, or rather why uranium enrichment is at all necessary.

In order to answer this question it is first of all necessary to explain what uranium enrichment is. It is known that uranium is one of the few natural elements having certain radioactive characteristics. This means that atoms of this element can be split with the accompanying liberation of great amounts of energy in the form of heat and atom particles which in turn hit and split other atoms creating the so-called chain reaction.

However, not all of the uranium's atoms have this fissioning characteristic and as a matter of fact only about 0.7 percent of the uranium's content is fissionable. This isotope (atomic variation) has three fewer neutrons in its nucleous than the vast majority of uranium atoms which have an atomic weight of 238. The lighter isotope has an atomic weight of 235 and is known as 235 U.

Although certain nuclear reactors can work well on natural uranium it has been found that the best results, in terms of cost effectiveness, can be obtained if the contents of isotope 235 U can be increased to about 3 percent instead of the approximately 0.7 percent present in natural uranium. This increase in the content of 235 U is known as uranium enrichment and comes down to removing from the uranium some of the more abundant 238 U isotope. Thus the more 238 U can be removed from the uranium or stripped away from it the higher is the degree of enrichment.

Differing degrees of enrichment are being used in different reactors. Commercial reactors such as employed in the Koeberg power stations use about 3 percent enriched uranium in their fuel elements. In reactors which are utilized for research and the production of radio isotopes for medical and industrial applications, such as the Safari Reactor of the Council on Atomic Power, medium to highly enriched uranium is used as fuel.

Originally all the enriched uranium needed for these purposes had to be imported, while South Africa's natural uranium was being exported; but now the local enrichment industry can already partially fulfill the requirements for research fuel and in time it will be able to provide all the commercially needed supplies.

The history of the South African uranium enrichment industry, which has finally led to the founding of the Uranium Enrichment Corporation of South Africa (UKOR), began about 20 years ago. In the light of South Africa's great uranium reserves (the second largest in the world) and the fact that the nuclear industry increasingly became bent upon using enriched uranium as the fuel, it was then decided to proceed with the development of our own enrichment industry.

At that stage the most popular process for isotope separation was the so-called gas diffusion process which was first perfected by Americans. The process comes down to having uranium in combination with flourine (uranium hexaflouride) pass through a membrane having a great number of tiny orifices in this gaseous state. The lighter atoms move faster through the membrane with the result that the gas behind the membrane is a bit richer in 235 U.

Another process which is now winning ground is the so-called gas centrifuge process by means of which the uranium hexafouride goes through a centrifugal process, somewhat like the old time cream separators, with the result that the heavier atoms move outwardly and some of the lighter isotopes can be separated.

The technology connected with both of these techniques is expensive and at that stage was still out of reach of South African capabilities. Moreover, those foreign entities having the know-how guarded their secrets jealously and it was clear that if we were to move in this direction it would come down to having to invent the wheel all over again. A whole new approach had to be followed.

A team of engineers and scientists, under the leadership of Dr A.J.A. Roux, now chairman of UKOR, and the present managing director of UKOR, Dr. W.L. Grant undertook this task with enthusiasm and dedication and within a few years came up with a process so unique and so effective that it had the international nuclear community guessing and buzzing. In 1971 this led to the establishment of UKOR under the chairmanship of Dr Roux who was given the order to proceed with the construction of a pilot plant meant to test out the process in actual operation. In 1978 the government announced that an expansion of the plant would be undertaken for the purpose of providing its own enrichment requirements in South Africa.

The land between the hills of Valindaba, where this new industry is springing up, is an ants' nest of activity. The buildings and structures being built for housing the production plant and the other related plants cover about 74,000 square meters. A special plant is under construction where the ammonium diuranate obtained from the mines will be converted into uranium hexaflouride gas and a flourine plant is also being built. In addition a hydrogen plant is under construction.

Although the further refinement of the UKOR process (a technique known as the helicon technique) has made possible the building of a more effective and more compact plant, the main processing room is still about five stories high and its floor space can easily accommodate two rugby fields. The ventilation towers, the points of which can be seen from the road, have already become a landmark in the surroundings.

Due to the fact that UKOR has depended heavily on inudstry, because of the many foreign attempts to obstruct South Africa's nuclear industry, its development has provided an important stimulus in the heavy and light precision industries. The engineering challenges which have arisen are almost unknown in the country and nearly every discipline of applied science has been able to make some contribution. Moreover, the many support functions which must be fulfilled have created jobs and challenges over a wide spectrum.

The necessity of establishing our own South African enrichment industry had already been shown by the problems experienced in obtaining nuclear fuel for Koeberg and by UKOR's having to provide medium enriched uranium to the Council on Atomic Power as a result of the U.S. refusal to meet its contract for supplying fuel for the Safari reactor. The mere existence of the industry is giving South Africa greater bargaining power in international neotiations and as the industry gets going it will be playing a greater role in protecting the country from international extortion.

Today the energy hungry world is subject to the whims and caprices of the countries controlling the major sources of energy. In the case of oil the Arab countries were to ones to blackmail the world during the past decade, while South Africa itself also had some hard experiences with the importation of nuclear fuel. But the fact still remains that the world's fossil fuel resources are not inexhautible and that, whatever opposition there may be, for the present nuclear power is offering the only viable alternative.

Actually the world is now in the threshold of an age which in the future will perhaps be known as the nuclear age. Thus nuclear fuel technology, and especially UKOR, have become an indispensable link in putting South Africa firmly on the road of this development.

7964
CSO: 5100/5649

FEDERAL REPUBLIC OF GERMANY

TECHNICAL ASPECTS OF THE WA-350 REPROCESSING FACILITY

Graefelfing ENERGIEWIRTSCHAFTLICHE TAGESFRAGEN in German /02/1982, V0032, N0002, pp 154-156

[Article by Graduate Engineer Joachim Mischke, member of the board of the DWK (German Company for Nuclear Fuel Reprocessing), and Graduate Economist Juergen Rehnelt, member of the staff of the board of the same company, Hannover]

[Text] 1. Basic Political Conditions

The policy decision arrived at jointly by the Federal Government and the Laender, which is binding until the year 1985, provides for the construction of a reprocessing facility--regardless of any decisions which may be made at that time [1]. In connection with this decision, the leaders in the Federal Land of Hesse have expressed their readiness to accommodate a reprocessing facility within their sovereign territory. However, the size of such a facility was restricted to 350 tons of throughput on the part of the Hesse policy makers. In view of the fact that such a facility would not be large enough to be able to cover future waste-disposal needs--discernible even after the third updating of the energy program of the Federal Government--other Laender have likewise declared their readiness to accommodate a reprocessing facility [2]. For the time being, a facility size of 350 tons of annual throughput forms the basis as well for similar but even more extensive waste-disposal considerations within the Federal Government and Laender.

This facility size--after being stipulated by the Hesse Land government and adopted in this form as the basic consideration by other Laender as well--made it necessary to readjust to smaller dimensions the technical planning for the original Gorleben facility, which had been committed to a throughput size of double this amount for each operational leg (1,400 tons of annual throughput). On the other hand, "large" plant components are already undergoing full-scale testing at a research unit of the Karlsruhe Nuclear Research Facility.

A reprocessing plant with an annual throughput of 350 tons (WA-350) represents only a 10-fold scale-up of the Karlsruhe Reprocessing Facility (WAK) with respect to annual throughput. For the most part, the scale-up factors for individual pieces of plant equipment themselves are even smaller. For example, for piping systems the aforesaid enlargement of throughput results in a scale-up of the flow rate of only about 1 : 3.

Contrary to a number of public debates, in creating new systems it is not unusual to develop such scale-ups (although in light of the already ongoing component testing, one must speak if anything about scale-downs). This is shown by examples in other countries. France and Great Britain are building facilities with throughputs which had been planned for the German Gorleben plant. In Japan, a 200-ton reprocessing plant was built and put into operation in Tokai-Mura practically from scratch--although with French help.

2. The Reprocessing Operation

In the WA-350 as well, the reprocessing of spent fuel assemblies works in principle as shown in Figure 1:

The spent fuel assemblies are unloaded from the reactor, stored for some time, and finally transported to the reprocessing plant. There the fuel assemblies are cut up into small segments and the nuclear materials contained in them are dissolved out by means of an acid treatment. This leaves behind the cladding, which is sent on to the waste-treatment section.

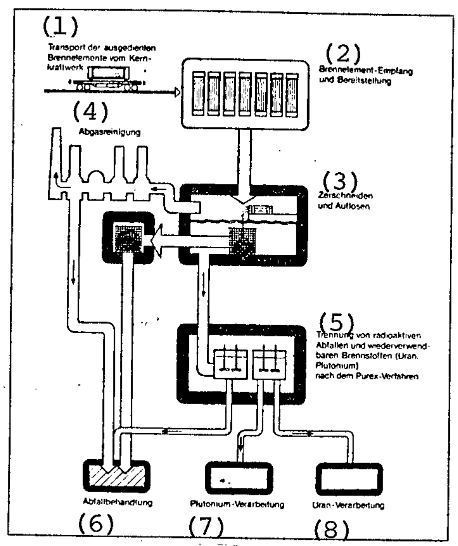

Figure 1: Schematic Diagram of Reprocessing System

Key:
1. Transporting of spent fuel assemblies from the nuclear power plant
2. Fuel-assembly receiving and readying
3. Cutting up and dissolution
4. Waste-gas purification
5. Separation of radioactive wastes and reusable fuels (uranium, plutonium) according to the Purex procedure
6. Waste treatment
7. Plutonium processing
8. Uranium processing

Through chemical techniques, from the solution thus obtained a separation is effected between the reusable materials uranium and plutonium and the non-reusable fission products which have formed during the operation of the reactor. In an additional step, uranium and plutonium are separated from one another and purified. The plutonium and a portion of the uranium is made directly into new fuel (mixed oxide), while the remaining uranium must be enriched again--just like the natural uranium directly recovered from a uranium mine--before it can be used for electricity generation in the nuclear power plant.

Depending on their material properties and radioactivity, the non-reusable fission products which have been separated out together with the waste products from the reprocessing operation are converted into forms suitable for ultimate storage, packed up, and finally put into an ultimate-storage reservoir.

To be used as a reprocessing technique is the PUREX method, in agreement with the systems being applied today in almost all countries with reprocessing facilities. The term PUREX stands for "plutonium-uranium-reduction-extraction procedure." It should be noted that this method is carried out at normal air pressure, in fact even at negative pressure to some extent, throughout the reprocessing cycle. The maximum temperature occurring in the reprocessing operation is no more than 130°C--with the exception of the vitrification of the wastes. This temperature is necessary only to dissolve the fuel-assembly pieces in nitric acid and to boil down the solutions. At all other points, the work is done at room temperature. It is also an advantage that the equipment used in this reprocessing technology is largely of a conventional type and is similar to the machinery used in other chemical production facilities, such as for example in petroleum refineries or in ore dressing systems [3].

Table 1: Main Characteristic Data of the WA-350

Throughput:	350 tons
Uranium component	330 t/a
Plutonium component	3.75 t/a
Fission products	16.25 t/a
Average initial enrichment of the fuel assemblies	3.6 percent by weight of U-235
Average burnup of the fuel assemblies	40,000 MWd/t
Cooling-off period of the fuel assemblies	7 years
Outgo to the ultimate storage facility	
Molds (glass blocks)	215 pieces/a
Tritium-containing water	1,350 m^3/a
Waste drums	11,100 pieces/a

The PUREX procedure was developed in the United States toward the end of the 1940's and was first used in the American Hanford Facility in 1954. So far, this extraction procedure has been used in the various plants around the world to process about 800,000 tons of uranium from military reactors, more than 30,000 tons of uranium from Magnox [gas-cooled graphite moderated] reactors, and about 1,000 tons of uranium from light-water reactors. This includes also fuel assemblies from American submarine reactors with burnups of about 100,000 megawatt-days per ton of uranium [4]. As a comparison: From German light-water reactors

the intention is to reprocess fuel assemblies with an average burnup of 40,000 megawatt-days per ton of uranium.

3. Design Aspects of the WA-350

Leaving aside an adaptation of the WA-350 to the special features of a specific site, the facility could have the form presented in Figure 2:

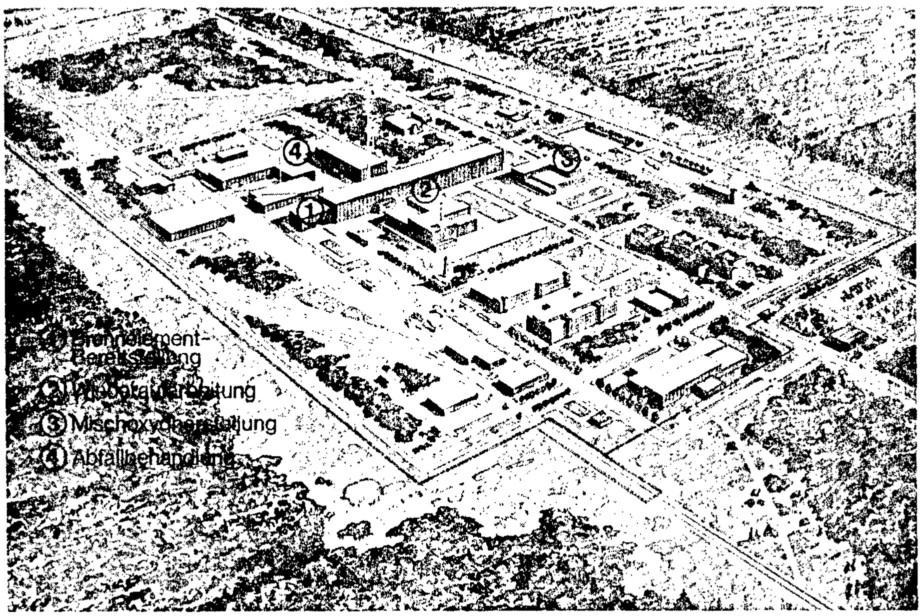

Figure 2: The schema shows how the reprocessing facility WA-350 might look, along with the most important plant components.

1. Fuel assembly readying
2. Reprocessing
3. Mixed-oxide production
4. Waste treatment

The overall plant complex consists of a number of processing buildings and installations for the infrastructure, such as power supply facilities, workshops, and so forth, which are connected to one another by plant roads and a rail system. The buildings will not exceed a height of 30 m and their foundations will be up to 10 m deep. A substantial portion of the radioactive materials is located in shielded processing cells, in some cases underneath the surrounding level of terrain. The walls, up to 2 m thick, and the retaining devices for radioactive materials guarantee the requisite radiation protection. All the control equipment and power-supply installations are positioned outside this wing. And the totality of processing cells and operating compartments are located under a sort of globe--the so-called "hard shell" made of reinforced concrete. Such a structure guarantees that even under actions from outside--such as, for example, an airplane crash--the integrity of the system is preserved.

The buildings in which slightly radioactive inventory is handled are designed as normal industrial structures, with due regard given to the necessary shielding. This applies, for example, to the processing stages for the after-purification of uranium and the cementation for weak-activity and medium-activity wastes.

As is shown in the layout plan, the power-supply building, the high-voltage switching facilities, the boiler house, and the water-treatment facility are set up apart from the processing buildings. The development of the plant grounds is effected both by rail and by road.

The general plant for the WA-350 differs from the integrated waste-disposal center above all in that the ultimate storage of radioactive wastes is not done at the site of such a plant. A Federal ultimate-storage facility designed for this purpose is to be established in Gorleben, provided that the relevant investigations on the salt dome turn out to be favorable (something which has not been made questionable by the studies done up to now).

In terms of process engineering, in essence nothing has changed. However, in many particular cases improvements have been made which embody the technical progress which has been achieved in the meantime. Moreover, because of the adjustment to a decreased throughput which has been made, it has proved possible to reduce considerably the scale of construction. The block diagram (Figure 3) shows schematically the operational steps in a WA-350.

In contrast to the Gorleben facility, no large interim storage area for fuel assemblies is planned at the WA-350 site. The fuel-assembly readying area has at its disposal a storage capacity of 200 t, which is needed on operational grounds, as compared to 3,000 t on the basis of the old plan. Transporting to the site and storage there is effected in shielded shipping and storage casks, which can accommodate up to 25 fuel assemblies, depending on the type.

The unloading of the fuel assemblies from the storage casks is done in the fuel-assembly receiving area. At the chemical head-end, the fuel pellets are dissolved out from the cut-up fuel assemblies. The separating off of uranium, plutonium, and fission products is done in the first extraction cycle. The second and third cycles serve the purpose of purifying the uranium or plutonium.

Based on the concept of the WA-350, a special advantage also arises with respect to the vitrification of the highly radioactive fission products.

Since the reprocessing facility receives only those fuel assemblies which have been stored for 7 years after their removal from the reactor core--during which interim-storage time the radioactivity inventory of the fuel assemblies decreases significantly--and since the planning assumes an immediate vitrification of the fission-product solution after their separation, only relatively small buffer tanks will be necessary for disassociating the procedures "extraction" and "vitrification," and the longer-term interim storage of highly active fission product solutions is dispensed with.

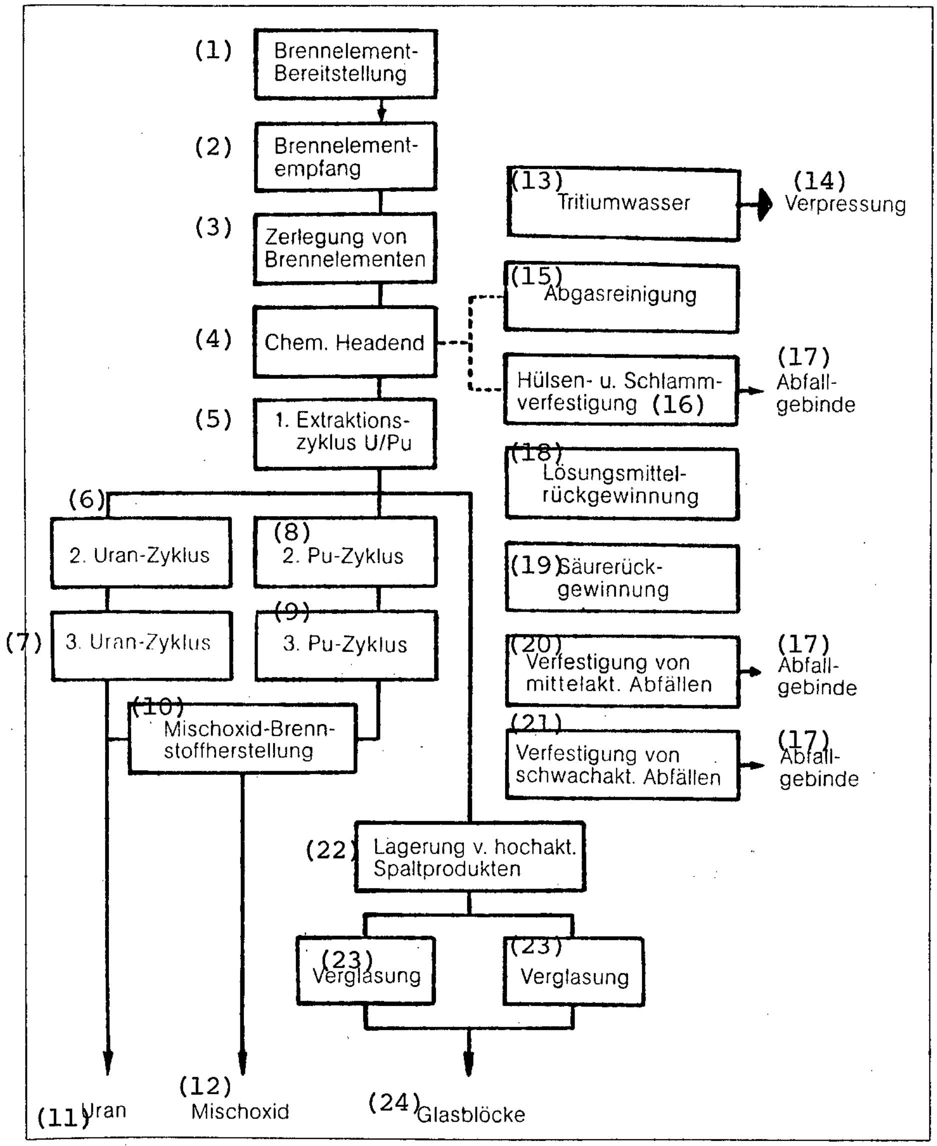

Figure 3: Block diagram showing the operational steps of a reprocessing facility for the upper throughput of 350 tons of uranium per year

Key:
1. Fuel-assembly readying
2. Fuel-assembly receiving
3. Cutting up of fuel assemblies
4. Chemical head-end
5. First extraction cycle, U/Pu
6. Second uranium cycle
7. Third uranium cycle
8. Second Pu cycle
9. Third Pu cycle
10. Mixed-oxide fuel production

[key continued on following page]

11. Uranium
12. Mixed oxide
13. Tritium water
14. Pressing
15. Waste-gas purification
16. Cladding and sludge solidification
17. Waste drum
18. Solvent recovery
19. Acid recovery
20. Solidification of medium-activity wastes
21. Solidification of weak-activity wastes
22. Storage of highly-active fission products
23. Vitrification
24. Glass blocks

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[1] See Bulletin of the Federal Government, No 122, 11 October 1979, p 1133 f.

[2] See also Bavarian State Legislature, Plenary-session Record 7/93, 6 March 1981, as well as the State Legislature of Rhineland-Palatinate, Plenary-session Record 9/36, 22 May 1981.

[3] See Baumgaertner: "Safety and Environmental Protection in Connection With Nuclear Waste Disposal," published by the federal minister for research and technology, Bonn, 1979.

[4] See "Arguments Pro and Con," record of statements made at the "Gorleben Hearings," First day, Hannover, 1979.

12114
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EXPERT DISCUSSES NUCLEAR INSTRUMENTATION RESEARCH, MARKET

Paris CEA NOTES D'INFORMATION in French Dec 81 pp 21-23

[Text of presentation given by Jacky Weill, head of the Nuclear Electronics and Instrumentation Department, at a colloquium at the Saclay Nuclear Study Center, 13-15 Oct 81: "Nuclear Instrumentation: How Far Have Research and Industry Gotten in France?"]

> [Text] "Electronic Information Days" were organized on 13-14-15 October 1981, at the Saclay Nuclear Study Center, by the Nuclear Electronics and Instrumentation Department [DEIN], in cooperation with various Electronics Units of the AEC.
>
> During those "Days," three major themes were touched on:
> . electronics and computer science at the service of medical instrumentation;
> . electronics, nuclear instrumentation, industrial development;
> . robotics, intervention in hostile environment.
>
> We are publishing below a presentation by Messrs Jacky Weill, head of the DEIN, and Rene Fabre, assistant to the head of the DEIN, which summarizes the research and development efforts in progress in the five sectors of this nuclear instrumentation and describes the status of French industrial activities on the basis of an estimate of the French market, of production, and of the flow of trade with foreign countries.

If the boundaries of the instrumentation market in France are not very precise, those of nuclear electronic instrumentation are even more difficult to define.

Considering the importance of research activities and of industrial activities in the nuclear fields, it would be desirable to know better the actual place occupied by this instrumentation, and its medium term prospects, as well as the situation of our industry, its performances and its competitiveness. Indeed, the results of scientific research, technological development and the high technology industries are closely linked to the quality of the instrumentation being used and increasingly require systems which resort to automation and to computer science.

For greater understanding and clarity, we will say that nuclear instrumentation is that which allows us to bring to the fore, to measure and to analyze nuclear phenomena or to control nuclear processes. It consists primarily of particle detectors accompanied by power supply, amplification, counting and selection mechanisms, and by computer systems for data processing.

For those various materials, we suggest a classification by major area of application:
- Health physics and radio-prospecting;
- Operation of nuclear reactors;
-- Operation of plants (development and reprocessing of the fuel, control of nuclear materials, etcetera);
- Instrumentation for research laboratories (power supplies for detectors, amplifiers, discriminators, NIM [Nuclear Instrumentation Modules] modular systems, CAMAC [Computer Application for Measurement and Control], analyzers, etcetera).

Research, Developments in Progress

The basic research takes place in laboratories of public institutions (AEC, universities, EDF [French Electric Company], etcetera) or of a few large manufacturers (CGE [General Electric Company], CSF [General Radio Company], RTC [possibly Compelec Technique Radio], etcetera); it does not usually produce short term industrial developments. Cooperation between public research institutions and industry is organized primarily for purposes of development.

In the technical area, the general trend in the work in progress lies in the creation of new sensors, the improvement of existing ones and the development of very "computerized" numerical measuring systems, which would allow the very short term acquisition of a large number of events as well as the on line calculation of their principal parameters in order to act both on the progress of experiments and on the control of industrial processes, or even on security systems.

The financing of this activity was estimated at approximately 40 million francs in 1980; it is high considering the volume of production, which was 260 million francs as we will see in 1980. This financing is provided by manufacturers (10 percent of the amount of their turnover) and by state institutions (DIELI [Bureau of Electronics and Data Processing Industry], DGRST [General Directorate for Scientific and Technical Research], ANVAR [National Agency for the Valorization of Research], AEC, EDF, etcetera).

Instrumentation for Research Laboratories

In this area, we will cite two examples which show the development of techniques:
- the development, at Berkeley, of an experimental set of 815 detectors to find out the number, the energy and the trajectory of the particles released into space by projectiles hitting the target;
- the development, at CERN [European Council for Nuclear Research], of an automatic calibration system, using a network of optical fibers (175 kilometers of fibers supplied by Quartz and Silice). This system includes 7,000 detectors (scintillators and multipliers).

One can imagine the complexity of the processing of the data provided by these detectors and the need to turn to computer science.

Automatic Operation of Nuclear Reactors

As a general rule, the research and development operations are carried out within the framework of national agreements with three parties (EDF, FRAMATOME [Franco-American Atomic Construction Company], AEC) or international agreements with four parties (EDF, AEC, FRAMATOME, Westinghouse).

Close cooperation has been developed between the EDF, the AEC and the relevant manufacturers (FRAMATOME, NOVATOME [expansion unknown], Merlin-Gerin, Radiotechnique, etcetera). It has been applied recently to studies concerning SPIN [Numerical Integrated Protection System], which has been approved and which will equip 1,300-megawatt power stations; the first industrial system will be installed at Paluel-I in 1982.

Research and developments in progress focus on:
- detectors, especially those placed in the core in order to improve knowledge of the distribution of the neutron flux within it;
- the replacement, in time, of the analog measuring blocks with programmed numerical units allowing a more thorough integration in the protection and operating systems of the power station;
- problems relating to the reliability and the security of the software;
- on-line analysis systems, especially concerning the evolution of fission products, of corrosion, etcetera.

Health physics and radio-prospecting

As far as health-physics installations and appliances are concerned, the research and development work is being applied to solving the very wide range of problems being encountered and to responding to two main objectives:
a) the management of data at a central level in order better to control the functioning of the installations;
b) the direct informing of the workers on the environment in which they work.

Thus, the research and development work in progress is concerned with the improvement of detectors and of the processing of information (microprocessor beacons connected to a central board, introduction of specialized software). Of course, they take into account the scope of our nuclear energy program (health physics in the power stations and in the plants which reprocess the fuel).

As for radio-prospecting, the effort of research and development is directed primarily toward improving the equipment to achieve a more rapid and more precise measuring of the uranium content of ores (special probes for diagramming and ore detectors connected to data processing mechanisms).

Control of Plants

The very significant needs resulting from the expansion of the La Hague plant require a research and development effort to produce numerical measuring chains

for the on line control of the processes (concentration and content measurements through gamma absorptiometry, special alpha detectors, etcetera).

Considering the evolution of the regulations, which are becoming increasingly strict in the area of control of nuclear materials, work is being done to improve the sensitivitiy and the security of fissionable material detection mechanisms (gates and beacons), and industrial developments have already been achieved.

Detectors

They play a basic role in all areas and the need to improve their performance is understandable. Important research and development efforts have been undertaken in terms of semiconductor detectors, particularly to allow functioning at room temperature.

Industrial Activities, Economic Data

In terms of turnover, nuclear instrumentation represents approximately 2 to 2.5 percent of that of the total instrumentation in France.

Figure 1 represents the evolution of the French market in the five sectors being considered. This evolution is characerized by:

. A growth of the French market between 1976 and 1980, from 112 to 210 million francs (an increase of 18 percent per year on the average) with, however, a falling off since 1978.

. An equally strong growth in production over the same period of time, going from 150 to 260 million francs (20 percent per year), which can be explained both by the development of the market, but also by an improvement of the rate of coverage of that market through national production (75 percent in 1976 to 80 percent in 1980).

. On the other hand, export performance has evolved less favorably (an increase of approximately 10 percent per year). The share of exported production dropped from 43 percent to 34 percent between 1976 and 1980.

. Finally, overall imports have been contained at an acceptable level (22 percent of the market in 1980), so that, in this field, the balance of foreign trade remains favorable.

Not all sectors perform equally well. Imports and exports are virtually nil in the area of control of reactors and of plants; hence, this is a national market covered by French manufacturers. On the other hand, looking more closely at statistics we are very familiar with, that is to say, those relating to the purchase of materials by the AEC, which are very representative, we find an alarming increase of imports in the sector of instrumentation for research laboratories (a key sector which is essential to the future). Figure 2 provides the evolution of the rate of imports by the AEC and in France. Between 1970 and 1980, these rates went from 8 percent to approximately 35 percent).

Medium-Term Projections of the French Market

These projections (Figure 1, dotted lines) are based on the following assumptions:

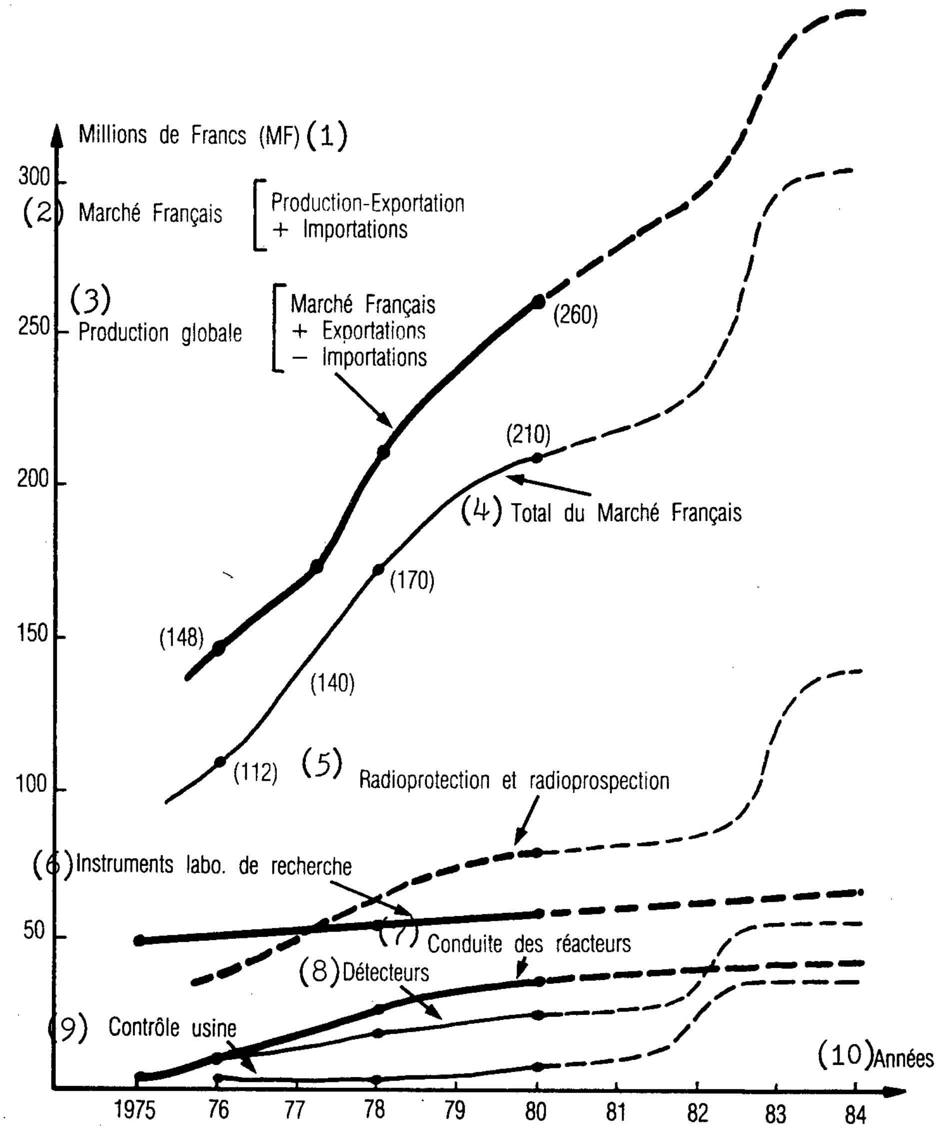


Figure 1. Development of French Market and of Production and Short Term Projections

Key:

1. Millions of francs
2. French market: production - exports + imports
3. Overall production: French market + exports - imports
4. Total of French market
5. Health physics and radio-prospecting
6. Instruments for research laboratories
7. Operation of reactors
8. Detectors
9. Plant control
10. Years

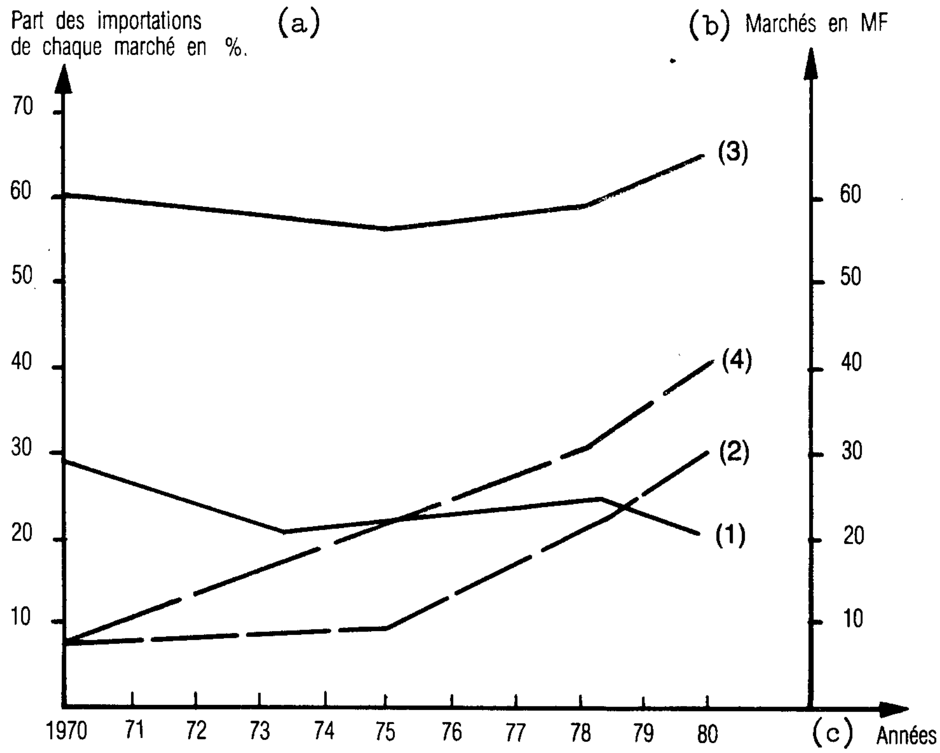


Figure 2. Instrumentation for Research Laboratories

- Evolution of AEC market (curve 1) in millions of francs and of the French market (curve 3) in millions of francs.
- Percentage of imports in both of these markets (curve 2 for the AEC; curve 4 in France).

Key:

a. Portion of imports in each market in percentage
b. Markets in millions of francs
c. Years

. A relative leveling off, in terms of volume, of expenditures for the equipping of power stations at the level reached in 1979.
. Beginning of an enormous effort to equip COGEMA [Nuclear Materials General Company] in 1982-1983.
. Stagnation, in terms of volume, of other expenditures.

The rather strong growth is due to the instrumentation for control of reprocessing plants, to detectors and to health physics.

Even though the projections seem favorable at the industrial level, there is a need to reconquer the French market for research instrumentation and to continue the effort in the other sectors in order to export more. It appears that, in spite of the narrowness of the gap, a national effort based on a European distribution base would be desirable and would be profitable.

A greater effort by the public authorities whose action, even if it is considered too modest, has made it possible to maintain this industry, should be located along the following axes:
. Development of support credits (for instrumentation as a whole, these credits were only on the order of 0.7 percent of the overall turnover in 1979).
. Development of cooperation agreements between research bodies and industry.
. Reduction of our dependence on foreign countries (United States and Japan) with regard to components (integrated circuits, very highly integrated circuits, microprocessors, etcetera).
. Aid specifically to small and medium size enterprises in order to promote innovation.
. Promotion of exports.
. Promotion of training in these sectors.

We will conclude by emphasizing, on the one hand, the unsatisfactory state of nuclear scientific instrumentation, and we have proposed measures to remedy this, and, on the other hand, the always favorable projections of the electronuclear market.

8463
CSO: 5100/2118

CHEMEX OUTLINES ITS URANIUM ENRICHMENT PROCESS

Paris REVUE GENERALE NUCLEAIRE in French Jan-Feb 82 pp 68-70

[Article by J.-C. Guais, head of the Chemical Engineering Section, CEN/Nuclear Studies Center/ Saclay, AEC [Atomic Energy Commission]: "The French Chemical Process for Uranium Enrichment"]

[Text]: 1. General Aspects of the Process

The process is innovative in that it makes practical use of the principle of an exchange between two uranium compounds that impart:

--an elementary enrichment effect to the equilibrium that is more intensive than that obtainable with known (thermodynamic) procedures heretofore;

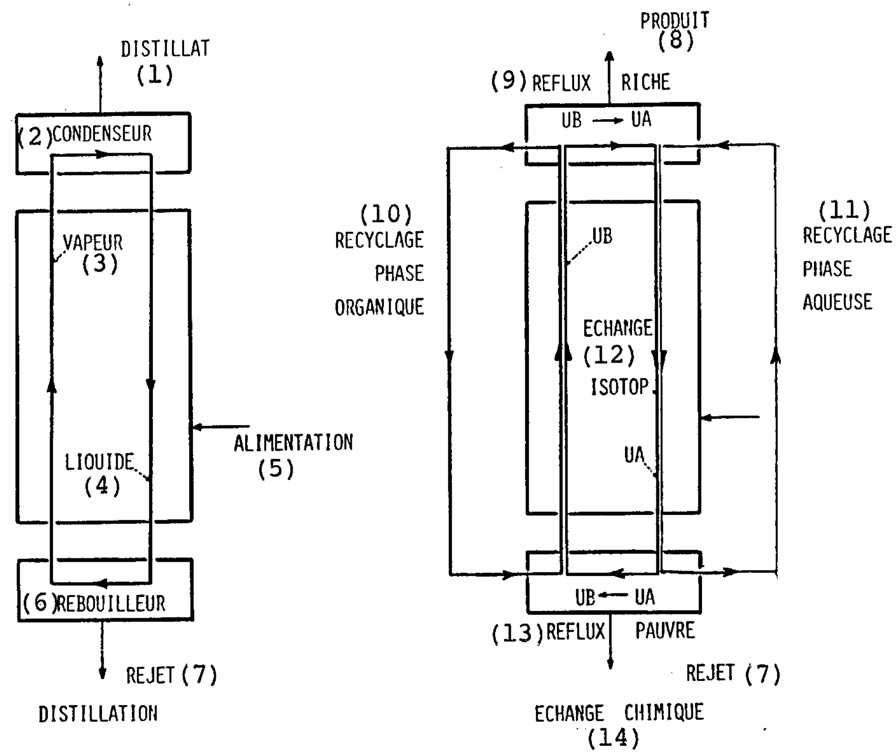
--a speed of attainment of acceptable equilibrium (kinetic), conditioned by the classical phenomena of diffusion of the species in the phases.

Repetition of the elementary effect is obtained by the countercurrent circulation of two immiscible liquid phases, each carrying preferentially or totally one compound.

The skeleton flow diagram of Fig 1 is reminiscent of mass-transfer processes of the distillation or, better yet, of the liquid-liquid extraction types, using exchange contactors of the conventional chemical engineering type (pulse columns), and reflux systems at both ends with an extremely high reflux ratio ($>10^3$).

It should be noted that the exchange operation is a reversible reaction, hence the consumption of energy is reduced to that needed for circulation of the phases, unlike reflux operations in which power requirements are intensive.

The relationship of the CHEMEX [expansion unknown] process to the overall cycle presents some interesting aspects, in that the conversion of the uranium (yellowcake) into the form required by the process is a simpler and less costly operation than converting it into the UF_6 form needed for enrichment by the gaseous diffusion of centrifugal separation processes. Also, the enriched output delivered by the CHEMEX enrichment plant can be easily transformed into UO_2 powdered oxide for the fabrication of fuel pellets.



Key:

1. Distillate.
2. Condenser
3. Steam.
4. Liquid.
5. Feed.
6. Reboiler.
7. Bottom product.
8. Product.
9. Enriched reflux.
10. Organic phase recycle.
11. Aqueous phase recycle.
12. Isotopic exchange.
13. Depleted reflux.
14. Chemical exchange.

Fig. 1 - Skeleton flow diagram of CHEMEX process.

2. Separation Performance

An indicator is used to characterize the specific separation capacity by unit volume of the medium: ΔU_6 in UTS [separative work units]/yr/m^3. This indicator measures in a way the "density of separation yield," which in turn directly conditions the volume of isotopic exchange installation required for a given capacity (separation yield).

It is to be noted that since 1977, when the existence of the process was disclosed at the AIEA /International Atomic Energy Association/ Conference in Salzburg, its specific yield has increased from 70 to UTS/yr/m^3 to more than 200 UTS/yr/m^3, that is, by a factor of 3.

A study of this trend and a knowledge of related thermodynamic, kinetic and hydraulic phenomena justifies expectations of a further evolution in the performance of the process towards an even higher value of this indicator by around 1985.

3. Technology

An important characteristic of the CHEMEX process is that it utilizes a type of technology derived from the conventional industries (chemical, extractive, petroleum), with adaptations to fit the particular characteristics of the process.

Materials

A broad program of testing made it possible to select materials satisfying the criteria of resistance to corrosion, passivity to chemical products, industrialization of the process and costs.

Plastic materials containing fluorine appeared to respond suitably to the cited criteria, either in solid form or as coatings.

Isotopic Contactors

The isotopic exchange takes place in large-sized pulse columns, connected in series so as to obtain the total number of stages needed for commercial enrichment of the product. These apparatuses are designed in widely varying diameters, between 100 mm and 1,200 mm, from the standpoints of mechanical strength, configuration, construction, hydraulics and separation yields.

Components

All the components of a CHEMEX installation were subjected to intensive studies and testing: reactors for the reflux and related operations, pumps, valves and circuits, measurement, monitoring and regulation functions.

4. Plant Design and Industrialization

The design of an industrial installation is based on standardization of all its components and modularization of the capacities to be attained progressively.

In fact, single types of equipment (contactors, reactors, pumps, ...) are used to design commercial units in accordance with capacity requirements:

--The pulse column used as the basic one for its projects has a diameter of 1,600 mm and a height of 30 meters;

--The cascade is a series of 20 columns. It yields commercial-grade enrichment (3-3.5 percent content), with high depletion (bottom-product content close to 0.2 percent). Its capacity is around 250,000 UTS per year, and it is the basic building block for further capacity growth scenarios;

--The module associates two cascades (Fig 2) to form an industrial unit of 500,000 UTS/yr, capable of expansion to meet the evolution of market demand: An increase in the enriched product content to respond to the demand of users wanting to lengthen reactor cycles, or variation of content of the bottom product in accordance with the evolution of prices of natural uranium.

This "flexibility" of the installation is a useful factor, given the uncertainties of the uranium and enrichment markets during the 1990's.

As regards industrialization, it should be pointed out that the use of moderate quantities of apparatus (a few tens to a few hundreds), as well as the emphasis on use of equipment already available on the market (particularly for many of the connected auxiliary functions), tends to do away with the need to create specific industries upstream of the installations, unlike the case of processes such as gaseous diffusion and centrifugal separation.

This explains its modest scale effect; that is, a fairly close economic viability for capacities ranging from 500,000 UTS/yr up to 2-3 MUTS [million UTS]/yr, for example. These characteristics can be of considerable interest to countries at a medium industrial development level and/or having a modest nuclear program.

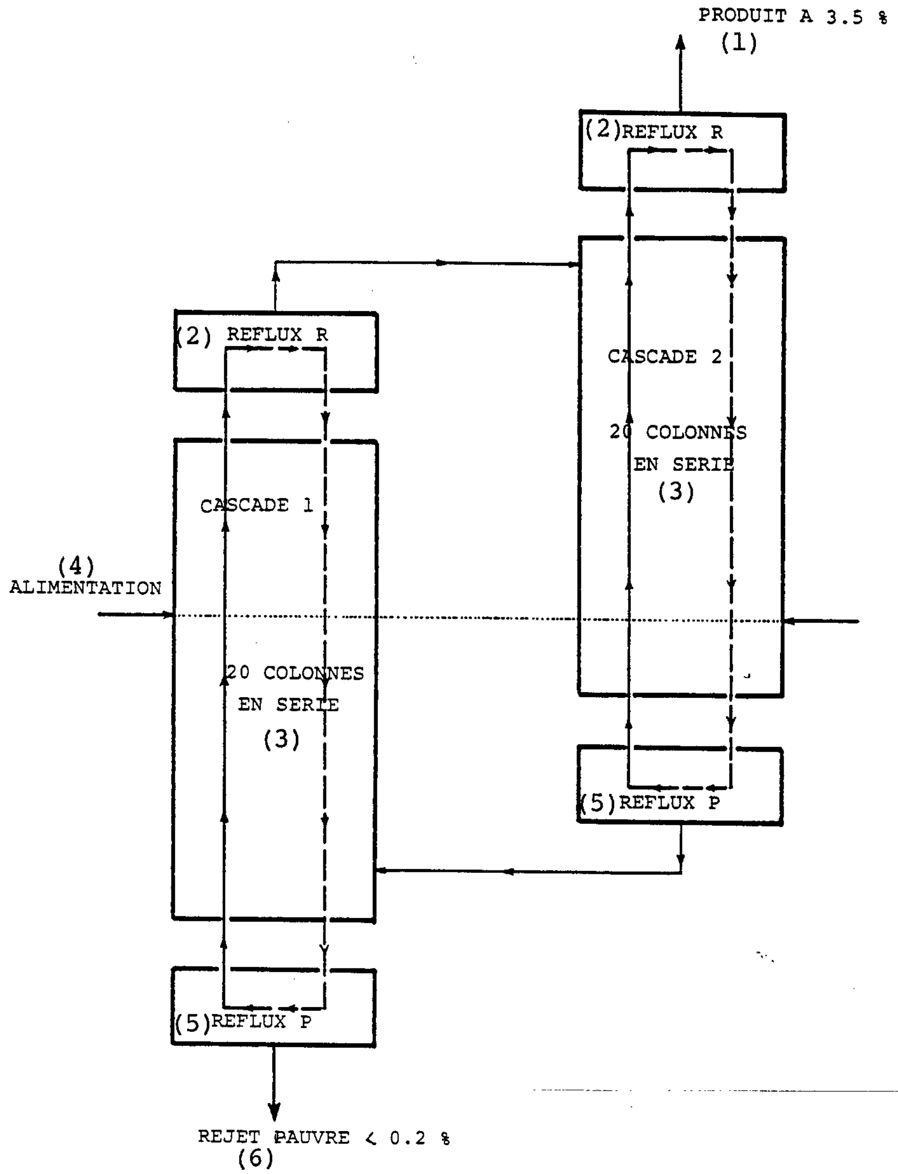
5. A Few Descriptive Details on a 1-MUTS/Yr Plant

For purposes of illustration, a few indicative details are given here for a "basic" 1-MUTS/yr capacity project:

--The plant consists of two modules;

--The total area occupied by the installation is no greater than 10 hectares;

--The plant uses 80 pulse columns 1,600 mm in diameter and 35 m high for the isotopic exchange;



Key:

1. 3.5-percent product.
2. Enriched reflux.
3. 20 columns in series.
4. Feed.
5. Depleted reflux.
6. Depleted bottom product 0.2 percent.

Fig. 2 - Industrial module: Association of two cascades.

--Energy consumed:

--Power requirement: 34 MW(E); that is,a specific consumption close to 300 kW-hrs/UTS, or 8 times less than for gaseous diffusion;

--Thermal energy: 100 tons/hr of low-pressure steam;

--Cooling water: Around 200 m^3/hr if water-cooled towers are used;

--Operations personnel: 300-350 persons;

--The economic analysis, in comparison with the other enrichment techniques, is given in the presentation by Mr Coates (see preceding text).

9399
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OVERVIEW OF CNEN'S NUCLEAR DEVELOPMENT PROGRAM

Rome RASSEGNA PETROLIFERA in Italian 26 Mar 82 pp 279-283

[Article: "An Overall Look at the Thermal Reactors"]

[Text] Light-Water Reactors

The year 1980 was one of profound rethinking of the role and type of activity carried on by the CNEN [National Nuclear Energy Commission]--mainly in the Thermal Reactors Department ("Term")--in the light-water reactors sector.

An organic CNEN policy in this sector was initiated in 1975, with the launching of the Industrial Promotion Program, the objective of which was to support the national industries in the effort to "internalize the licenses" and to maximize the contribution of Italian work in the building of the power plants. The instruments used for activating this program were mainly the "contracts of association" entered into by the CNEN with the country's principal nuclear industries.

Within the framework of these contracts, the CNEN has carried out the double role of evaluation of the "profitability" of the development program proposed by the industry, both in terms of the firms' interest (raising the technological level, increasing market share, adding to defense against the foreign competition; negotiation on more suitable bases of the relationships with the licensor), and in terms of more general interests of the country (improvement of balance of payments; increasing number of job positions; adding to export capacity; higher objective security of the power plants through greater and more intimate knowledge of the power plants themselves) and of participation in carrying-out of activities through the country's own research laboratories.

The logic followed in the establishment of the contracts of association has been that of the "bilateral relationship" between the CNEN and each industry on most of the topics of interest to it. The initiatives taken by the CNEN within this logic are as reported below, with indication of the reactor system involved:

--core system: Consorzio Nuclital AMN (BWR [Boiling-Water Reactor]); SOPREN contract of association (PWR [Pressurized-Water Reactor]); ENEL [National Electric Power Agency] collaboration agreement (BWR, PWR);

--plant: AMN contract of association (BWR); SIGEN contract of association (PWR);

--components: Fiat contract of association (PWR); Breda contract of association (PWR, BWR); Belleli research contract (PWR);

--safety: CISE collaboration agreement (BWR, PWR); Italia-CCR Ispra convention (BWR, PWR).

The personnel of the CNEN and of the industries concerned who were involved in the 1980 program were distributed as indicated in Table 1.

Table 1--Distribution of Personnel

CNEN	Thermal Reactors Department	Other Departments	Total
Association with industries	23	15	38
Activities with ENEL and support activities	121	29	150
Total	144	44	188
AMN			
Fiat (not including Marelli-Terni personnel)			70
Breda (including FBM [expansion unknown]-Ansaldo activities			24
SIGEN-SOPREN			20
FBM-Ansaldo			4
CISE			9
Belleli			12
Total for industries			171
Grand Total			373

As a result of the Fiat-Finmeccanica agreement, which made it possible to start, through unification of the two preexisting groups (for BWR and PWR reactors, respectively), rationalization of the industrial structures responsible for the designing of both types of reactor, the CNEN too has reconsidered its mechanism for taking action in the sector through the Industrial Promotion Program, pursuing the more general objective of contributing to rationalization of the entire supply market.

It is indeed a primary national interest not only to unify the design structure and the product to be built (a single system) but also to identify and define, with programming done as far ahead of time as possible, the specific contributions that the component industries must put out for implementation of the national nuclear program.

In order to achieve this objective, the logic was followed of considering the product or the product family as the aggregating element and of activating, on the basis of a program extending over several years for development of them in the national and international markets, multilateral collaboration between the CNEN and all the principal industries involved in the product considered.

On the basis of this approach, restructuring of the program aimed at development of the following "products" has been worked out and agreed upon with the industries:

--system-oriented designing of the Nuclear Island;
--nuclear boilers;
--fuel loads;
--heat-exchangers;
--instrumentation;
--turbogenerator sets;
--minor components.

The "Management Consortium," composed of the CNEN and the industries involved, and with the participation of the ENEL and of the Sistemista so as to ensure the maximum transparency, on the way toward the activities carried out and toward the results gradually achieved also, has been specified, in a general way, as the instrument for implementing the new type of programmatic approach.

In addition to the abovementioned activities, the program comprises a direct collaboration with ENEL and the national Sistemista for development of the unified project, and finally, a connection with DISP for development of research for the purposes of licensing.

In parallel with the studies and the negotiations on the restructuring of the Industrial Promotion Program, the activities are being carried on within the framework of the existing structures; the principal results are reported below.

Consorzio Nuclital--The activities relative to this consortium, which was liquidated on 31 December 1980, were put, in July 1980, in the CNEN-AMN contract of association, and involved the following concerns:

--development of the thermohydraulic designing of the core, of the fuel and of the experimentation, in collaboration with GE also;

--assistance in the operation of Caorso and collection of data relative to the behavior of the core and of the fuel.

CNEN-AMN Contract of Association

The activities carried out in association have generally enhanced the acquisition of knowledge about the BWR process, in accordance with the specific requirements set by the ENEL, with the objectives of:

a) a gradual transfer to the Italian industry of the "design engineering" activities, for which the licensor or foreign consultants have traditionally been commissioned;

b) internalization and perfecting of the design methodologies that are important for safety, in accordance with the international standard and the specific national standard.

The most significant results achieved are:

--study of jet forces: the study and experimentation activities carried out in Casaccia and at Genoa (Boschetto) have made it possible to take on AMN work commitments equal to 70,000 hours of work, which were initially expected to be assigned to a United States engineering company;

--start of installation of equipment for seismic checkout of components up to 7 tons and with vibration fields on two combinable axes (three in future);

--start-up of experimental program for checking out the containment-atmosphere hydrogen sensors;

--carrying-out of the experimental program at Casaccia on hydroponic cultures for reduction of the surface of the power plants' cooling pools.

CNEN-Breda Contract of Association--The original objective of the program was to enable Breda to maintain and improve its position in the international market as regards the steam-generator component, and more particularly, to improve its knowledge of the products at the level of simple fabrication from the design and under the monitoring of the foreign customer, and to acquire legitimacy through independent development of components and establish a peer relationship with the licensor, as a premise for an active presence in the national and international markets.

The work topics already taken up in the recent years have led to the following principal results, among others:

--for study of the behavior of the steam generator, testing has been conducted at Casaccia on fluid dynamics (Erica circuit), while construction of another two experimental installations (CFA and CPPC), for study of the dynamics and behavior of materials, has been started;

--for development of the components of the steam generator (steam separator, grid), development and testing activities using sizable experimental equipment is in progress, in collaboration with Westinghouse also; this equipment is presently being installed at Casaccia (Aramis circuit) and at the CISE (Gest circuit);

--for fabrication of the steam generator, the technologies-development activities are being carried forward: single-piece extrusion of the steam-generator floor complete with outlets and manholes; various welding methods (hot-wire, submerged-arc, narrow-iron, TIG for different applications (ferrules, outlets, tube plate, etc). [as published]

Within the framework of the CNEN-Breda association, a detailed study has also been completed on the feasibility of an experimental program in support of the development of the supply-water preheater, which will be the subject of a new form of association to be established with Ansaldo-FBM.

CNEN-Fiat Contract of Association--As the general outcome of all the activity so far carried out, Fiat has asserted its capacity to furnish high-technology components, not only on the national market--for which it is especially significant that it is negotiating, among other things, for the supplying of the pumps for the Montalto di Castro power plant (as an alternative to GE)--but also on the international market, in which some interesting prospects, especially for the French program, have opened up.

In 1980, the following results were achieved in particular:

--primary pump: the prototype of the pump is in the assembly stage, and installation of the test circuit, whose components have been made by Italian industries, has been started;

--control mechanism for control rods: the pretesting phase has been started in the circuit for that purpose. The fabrication technologies for all the mechanical components inside the vessel (support plates, grids, guide-tube structures, etc) have practically been perfected. A centralized radiation-monitoring system to be tested out at Saluggia has been finished by SEPA [Society for Electronic Automation] (Fiat), and Gilardini (Fiat) has completed a model of a damper for the primary-tubing connectors.

CNEN-SIGEN-SOPREN Contract of Association--As a general consideration, it should be noted that the activity related to the CNEN-SIGEN-SOPREN association has made it possible to orient and strengthen the small team of technicians working on the topic of the pressurized-water system; this team had been tending to break up because of lack of activity in this specific sector. It has also been possible, on this basis, to maintain and renegotiate a suitable licence relationship with Westinghouse.

The most significant results achieved in 1980 are the following:

--the computer models necessary for the thermomechanical designing of the fuel rods were determined, and a series of expansion and bursting experiments on zircaloy cladding was carried out in the CNEN's laboratories;

--a three-dimensional computer code that does the coupling between neutronic and thermohydraulic variables in core analysis was completed;

--the safety analysis of a PWR installation in case of rupture of the steam channel was established, and a computer model on rapid introduction of boron into the core during a Loca [refrigerant loss] was developed.

CNEN-CISE agreement on collaboration in research activities on the safety of water-type reactors: at the end of 1979, a safety-research program was launched in the CISE, complementing the safety-interest activities conducted by the industrial-promotion program and directed toward objectives indicated by and agreed upon with the DISP, which for this program is tending to take on the position of customer.

The entire program is in the phase of startup and preparation of the experimental equipment; therefore, definitive results have not been achieved yet. The research topics under way relate to: the thermohydraulic behavior of the PWR's pressurizer during transitions, the behavior of a PWR steam generator's nest during transitions, the thermohydraulic transitions of a BWR core and of the primary circuit with malfunctioning of the control system. The experimental program for these activities has been defined through detailed feasibility studies, and the designing of the test equipment is in progress. Another line of activity relates to the studies on the mechanics of fractures. Computer codes have been developed and experimental tests have been carried out for verification and validation of them.

CNEN-ENEL Collaboration Agreement--Within the framework of this agreement, the CNEN has brought together the activities carried out in collaboration with its system-oriented industrial partners (AMN and SOPREN) relative to development of the fuel and of the core. Through the CNEN it has therefore been possible to achieve a very productive relationship of collaboration between industry and ENEL--collaboration that in the past had proved difficult because of the reciprocal "supplier" and "customer" position.

The principal themes of the collaboration have concerned the collection of data from the operating of Caorso; preparation of experimental fuel elements; development and certification of computer codes for description of core behavior in stationary conditions and incident conditions by means of models that are alternative or that integrate the license models.

Research Contract with the Belleli Company--The contract is aimed at development of heat exchangers made of low-cost thermoplastic material, to be used in wet-dry cooling towers with forced draft to be used for power plants located at sites with limited water availability.

Several solutions for construction problems with the exchanger have been optimized so far, and modification to wet-dry of a tower operating wet has been completed; collection of the experimental operating data for this tower is in progress. Processing of the data may verify the design hypotheses. The first obvious result has been abatement of the exhaust fumes.

A large proportion of the financing for the Industrial Development Program has been used for building a series of test circuits, equipment and special machinery that in toto represent a large investment at the national level. This equipment has been concentrated in experimental areas that are located mainly in the major users' establishments but are planned to be capable of use in a centralized manner to the benefit of all interested national operators.

Within the framework of the Industrial Promotion Program, the CNEN is also conducting activities not directly included in the collaboration agreements with industry but in reality closely purpose-directed toward the activities of the contracts. They generally involve programs oriented toward safety topics and directed mainly toward study of separate effects and basic phenomenologies that result in knowledge broadly usable for both of the systems.

In particular, the international-cooperation activities relative to the behavior of fuel-element models under irradiation are being carried forward. These activities are being conducted by the CNEN, AGIP [National Italian Oil Company]-Nucleare, AMN and SIGEN-SOPREN on a collaborative basis.

Heavy-Water Reactors: Cirene Prototype

The activities relative to the construction of the Cirene prototype were carried forward on a regular basis in 1980. On the level of general project management, two notable events occurred:

--the contractual relationship with the NIRA [Italian Nuclear (Company) for Advanced Reactors] was updated in order to take the increased design com-

mitments into account and to define the modalities of reimbursement for the installation activities, on the assumption that the loading of the fuel into the reactor will take place in 1983;

--a new structure was adopted for the ENEL organization that carries on the ordering activities.

The action of the overseeing authorities was continued, both for the purposes of approval of the Detailed Design Reports and for implementation of oversight of the components and systems being built; recourse to the specifications-fulfillment certification procedure was limited to the absolutely necessary cases only.

The state of advancement of the work can be summarized as follows:

--the Nuclear Island design activities are close to completion, though the safety analyses and the programs for the operational software for the reactor supervision and control systems are continually updated. As regards the conventional part of the installation, the analyses of the buildings and the writing of the order specifications for the systems are in progress;

--deliveries: almost all of the orders for the systems and components of the Nuclear Island have been made, and construction work on the Nuclear Island has reached an overall average of more than 35-percent completion; some of the principal components (primary pumps, steam compressors, control system) are close to the final checkout phase. As regards the conventional part, the construction work on the turboalternator set and the condenser, which are the components that take the longest time to deliver, is in progress at Ansaldo. Table 2 lists the principal items ordered from Italian industry;

--civil-engineering work: the upper structures of the two most demanding buildings of the Nuclear Island (the reactor building and the pool building) are under construction; they have been set on deep foundations;

--state of authorizations: 20 of the 22 Detailed Design Reports into which the installation has been subdivided have been presented to the CNEN's Central Department for Nuclear Safety and Health Protection (CNEN-DISP), and 11 of them have been approved; since only a few of those not approved yet are of considerable complexity, the state of advancement of the authorization procedures, as regards the design aspects, can be estimated at about 70 percent;

--research and development: the design-support and construction-support activities have reached their concluding phase; the studies of greatest importance that are still in progress have to do with full-scale checking of the behavior of the fuel column under vibration, and the maintenance of the installation.

The principal work done in the various areas of activity in 1980 are illustrated below.

The design work has progressed satisfactorily in its various articulations. In the civil-engineering sector, working drawings for the reactor building have been prepared (65-percent completion), as well as those for the waste-pool building (30-percent completion), while the operational project (including the stress analysis) for the control-room and diesel buildings is in an

advanced stage of preparation; the geotechnical study for the foundations of the remaining buildings has been completed, and studies and checks of the structural stability of the buildings themselves have been conducted.

Table 2--Principal Italian-Industry Suppliers for Cirene

Supplier	Item	Order Date
Ansaldo	Turboalternator and condenser	October 1979
	Sequence and interblocks	November 1980
ATB	Cylindrical body	September 1977
Belleli	Metal container	February 1978
	Heat exchangers	May 1980
	Mechanical assemblies	October 1980
Breda Termomeccanica	Reactor assembly	February 1974
	Power channels	March 1978
Castagnetti	Solidification of radioactive wastes	June 1979
Cimi	Metal container floor	September 1974
	Water containment system	September 1974
CMI	Fuel-exchange system	February 1979
Dalmine	Tubing	October 1979
Fiat	Fuel transfer and storage system	April 1980
Hartman Braun Italia	Neutron instrumentation	May 1980
Massobrio	Inserts for civil-engineering work	November 1978
Nuovo Pignone	Startup compressor	December 1977
	Primary safety valves	February 1979
	Control valves	July 1979
Riva Calzoni	Tube-closing plugs	November 1980
	Components for fuel-exchange system	November 1980
SCAI [expansion unknown]	Non-nuclear tanks	August 1979
SEPA	Radiation monitoring system	August 1980
Zanon	Biphase rods	December 1979
	Heat exchangers	July 1979
Zerbinati	Overhead traveling crane for handling containers	March 1980
	Protective doors	October 1980

As regards the fluid systems, conclusive analysis of the tubing of the primary heat vector and its auxiliary equipment has been carried out; the contract specifications for almost all of the components have been issued; the plant layout has been defined; and the detailed designing of the ventilation system has begun.

The designing of the electrical, firefighting and communication systems has been completed; for the protection, instrumentation and monitoring systems, the contract specifications for the principal components have been prepared and preparation of the operational programs for the direct digital-control system has been started; and the neutronic and thermohydraulic design of the core and the thermomechanical design of the fuel, substantially completed in 1979, have been subjected to detail checks.

In the area of supplies, the principal orders placed in 1980 were those for the electrical panels, the nuclear-instrumentation system, the radiation-monitoring system and the sequence and interblock system; and the invitation to bid on the gaseous-effluents discharge installation, the ordering of which is planned for Spring 1981, has been published. The work is behind schedule in some cases, either because of the difficulty of obtaining, even in the international market, electrical and instrumentation components that meet the qualifications set out in the IEEE norms applicable to Cirene, or because of the complexities in application of the quality-assurance program, or because some Italian suppliers are producing components for the nuclear market for the first time.

The activity relative to the awarding of the principal installation contracts began in 1980 also: in particular, the contract for prefabrication and installation of the tubing and for installation of the mechanical equipment, and the contract for the raising of the big components, have been awarded. During the year, the civil-engineering work relative to the reactor and waste-pool buildings continued without a break: the foundation slabs for the two buildings were laid in the first and third quarters of the year, respectively, and installation of the bottom liner of the reactor building's metal safety container was installed in the second quarter; the concrete heat shield overlying the bottom itself was installed at the same time.

Following that, the construction work on the upper structures could begin, and its state of advancement is as follows: for the reactor building, the external annular galleries have been completed and the upper vertical structures inside the primary container were started, while for the waste-pool building, the upper structures in the pool zone only are at an advanced stage of construction.

In addition, the laying of the poor concrete up to the foundation slab of the connecting body between the reactor building and the turbine building has been completed.

During the second half of the year, the prefabrication, at the base of the structure, of the water-containment tank of the Reactor Assembly was done, and an installation test of the whole--which is quite complex, being composed of the tank itself and of the armatures and inserts of the concrete biological shield, which surrounds it--was started.

Within the framework of safety activity of obtaining of permits [as published] the issuance of 20 Detailed Design Reports (RPP) out of the total of 22 planned has been completed, while the approvals related to them are proceeding at a rate slower than planned; in the first half of 1980, two (for the sprin-

kler system and the control-room building) were approved, and one at the end of the year (the control-room ventilation system), bringing the total number of RPP's approved so far to 11.

The 1980 research and development activity in support of construction of the prototype involved the definitive checking-out--for safety-analysis purposes also--of several design solutions adopted, transfer to the industrial level of the knowledge acquired in the laboratory, checkout of supplies of preseries components that will be installed in the reactor, and finally, identification of knowledge and techniques that will be useful for solving the problems of operation of the prototype.

With these end-purposes in mind, the drops of pressures and densities in biphase mixtures flowing in low volumes in large-diameter tubes have been determined, in the area of thermohydraulics; in the field of mechanics, the tests of behavior and duration and the Zircaloy-steel connection of the power channel have continued, the procedures for replacement of the insulation tubes during the initial installation phase have been defined, a preliminary investigation has been made of the procedures for replacement of insulation tubes in the initial installation phase [as published], a preliminary investigation has been made of the procedures for inspection of the Cirene channels, development of an acoustical-broadcasting system for signaling small breaks in the feeders has continued, and finally, the technique for formation of ice plugs for isolating circuit sections on which maintenance work is to be done has been experimented with on a small scale.

In the area of dynamics and control, the checking-out, in the pile, of the fission microchambers to be used in the core instrumentation has been completed, and the results of the tests for determining the limits of stability of the channels in parallel during the startup phase have been worked up.

On the topic of safety, experimental analysis of the temperature reached by the fuel under conditions of refrigerant loss ("Loca") has been completed, and a final document on the effects of a hypothetical bursting of the pressure tube has been prepared.

In the area of chemistry, several decontamination techniques have been checked out, and the collection of data relative to corrosion of carbon steels in various environments has been completed.

On the topic of the fuel, the irradiations in the Cart di Essor circuit in the Halden reactor for the in-pile qualification tests of rods and bundles of the prototype, both under stationary conditions and in power rises have been completed: for the execution of these last-mentioned tests in the NRX reactor in Canada, a test ring was constructed and the rods already irradiated were transported from Halden to Chalk River. Construction has been completed, and operation of the experimental circuit designed for the verification tests has begun.

Updated estimates of the times for completion of the prototype indicate starting of the loading of the fuel into the reactor in Spring 1984.

Many interacting causes have produced postponement of the target dates: some are of a financial and programmatic character, occasioned by uncertainty about the availability of the necessary financing; others are of an organizational and management nature (quantitative shortage of CNEN-DISP structures assigned to licensing, pressing commitments in the Ordering units regarding the nuclear and conventional power plants, limitation of CNEN personnel participation in these activities); and others, finally, involve the operational area (unforeseen technical difficulties, or difficulties arising from application, for the first time in Italy, of the most recent norms on licensing and on the quality-assurance program).

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